


REMARKS:

- 1) Examination of the present U. S. National Phase Application is to proceed on the basis of claims 25 to 47. Claims 25 to 47 are directly based on the PCT International Application claims 1 to 3 and 5 to 24, incorporating the amendments under PCT Article 19 of July 18, 2000 and the amendments under PCT Article 34 of December 21, 2000, as literally translated into English, except for omitting multiple dependencies.
- 2) It is noted that the International Preliminary Examination Report finds favorably that all International Claims 1 to 3 and 5 to 24 (corresponding to new U. S. claims 25 to 47) satisfy all criteria for patentability.
- 3). Favorable consideration and allowance of claims 25 to 47 are respectfully requested.

Respectfully submitted,

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S P E C I F I C A T I O N

NONAQUEOUS ELECTROLYTE SECONDARY BATTERY

5 TECHNICAL FIELD

The present invention relates to nonaqueous electrolyte secondary batteries as generally represented by lithium secondary batteries, and particularly to load characteristic improvements of positive electrode material after cycling.

10 BACKGROUND ART

In recent years, nonaqueous electrolyte batteries which use metallic lithium, alloys capable of storage and release of lithium ions or carbon materials for the negative active material and lithium-transition metal complex oxides for the positive electrode material have been noted as high-density batteries.

The use of a lithium-cobalt complex oxide (LiCoO_2), lithium-nickel complex oxide (LiNiO_2) or lithium-manganese complex oxide (LiMn_2O_4), among the lithium-transition metal complex oxides, for the positive active material results in obtaining high discharge voltages of 4 V class, particularly increasing battery energy densities.

Among the above-listed complex oxides useful for the positive active material, a spinel lithium-manganese complex

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oxide (LiMn_2O_4) is regarded as promising from viewpoints of price and stable supply of raw material.

However, there still remains a room for improvement in the use of such a lithium-manganese complex oxide (LiMn_2O_4) for the positive electrode material. Specifically, this spinel complex oxide shows a marked reduction in capacity with charge-discharge cycling, compared to lithium-cobalt and lithium-nickel complex oxides which do not have a spinel structure.

As one solution to this problem, M. Wakihara et al. reports that the reinforcement of a crystal structure by substitution of a dissimilar element, such as Co, Cr or Ni, for a part of Mn atoms in the spinel lithium-manganese complex oxide (LiMn_2O_4) improves cycle characteristics (see J.Electrochem.Soc., Vol.143, No.1, p.178 (1996)).

However, such substitution has been still insufficient to improve cycle characteristics because of the following reason. As the spinel lithium-manganese complex oxide undergoes expansion and shrinkage during every charge-discharge cycle of a secondary battery, active material particles also undergo expansion and shrinkage. This reduces a strength of the positive electrode and causes insufficient contact of the active material particles with current collector particles, resulting either in the reduced utilization of the positive electrode or in the fall-off of